

# Prevalent, uncontrolled, and undiagnosed diabetes mellitus among urban adults in Dire Dawa, Eastern Ethiopia: A population-based cross-sectional study

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## Abstract

**Objective:** Globally, 8.8% of adults were estimated to have diabetes mellitus, with the low-and middle-income countries sharing the largest burden. However, the research evidence for targeted interventions is lacking in sub-Saharan Africa, particularly in Ethiopia. Therefore, this study aimed to assess the prevalence of diabetes mellitus, disaggregated by the epidemiology of diabetes mellitus morbidity and associated factors among adults in Dire Dawa town, Eastern Ethiopia.

**Methods:** Data from a total of 872 randomly sampled adults aged 25–64 years were obtained for analysis using the World Health Organization STEPwise approach to non-communicable disease risk factors surveillance instruments. We estimated the prevalence of diabetes mellitus disaggregated by the previous diabetes mellitus diagnosis status and by the current blood sugar level control status. The bivariable and multivariable binary logistic regression model was used to identify correlates of diabetes mellitus, along with STATA version 14.2 for data management and analysis. All statistical tests were declared significant at  $p$ -value  $< 0.05$ .

**Results:** 14.9% (95% confidence interval: 12.1, 17.4) of adults aged 25–64 years had diabetes mellitus in the study sample with 58.5% (95% confidence interval: 49.7, 66.7) on diabetes mellitus medication. Among adults currently taking diabetes mellitus medications, 30.3% (95% confidence interval: 19.8, 45.6) had uncontrolled diabetes mellitus. The magnitude of previously undiagnosed diabetes mellitus was 6.2% (95% confidence interval: 4.8, 8.0) in the study sample and 41.5% (95% confidence interval: 33.3, 50.3) among the diabetics. The odds of diabetes mellitus were higher among adults over the age of 55 years (adjusted odds ratio = 2.1, 95% confidence interval: 1.2, 3.6), currently married adults (adjusted odds ratio = 2.3, 95% confidence interval: 1.2, 4.4), and overweight adults (adjusted odds ratio = 1.6, 95% confidence interval: 1.1, 2.1). Adults with primary education (adjusted odds ratio = 0.4, 95% confidence interval: 0.2, 0.8) and no formal education (adjusted odds ratio = 0.5, 95% confidence interval: 0.2, 0.9) had lower odds of diabetes mellitus.

**Conclusion:** The prevalence of diabetes mellitus among adults was high in Dire Dawa, with a third of the diabetics having poor control of their blood sugar levels and, nearly four in ten were previously undiagnosed. Adults who were overweight, currently married, and those over 55 years need to be targeted for regular diabetes health checkups and community-based screening. Also, a mechanism should be instituted to track a patient's adherence to medications and promote diabetes self-care management.

## Keywords

Adult, diabetes mellitus, Dire Dawa, undiagnosed diabetes, STEPS survey

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## Introduction

Diabetes mellitus (DM) is a chronic disease caused by an inherited and/or acquired deficiency in the production of insulin by the pancreas, or by the ineffectiveness of the insulin produced.<sup>1,2</sup> The global prevalence of DM among adults over 18 years of age rose from 4.7% in 1980 to 8.8% in 2017.<sup>3–5</sup> In 2015, an estimated 4.0 million deaths were directly caused by DM.<sup>3</sup> Almost half of all deaths that occur before the age of 70 were attributable to high blood glucose. The World Health Organization (WHO) projected that DM will be the seventh leading cause of death in 2030 and by 2045, it will affect 628.6 million people worldwide.<sup>2</sup>

Previously thought to be a disease of the affluent, DM is now rapidly increasing in low- and middle-income countries (LMICs). The International Diabetes Federation (IDF) estimated in 2017 that more than 79% of people with diabetes live in LMICs.<sup>3,6</sup> In the African region, the proportion of all deaths due to DM that occurring before 60 years of age was estimated to be 77.0%.<sup>3,7</sup> Specifically in Ethiopia, 3.8% (4.0% males and 3.6% females) of the population had diabetes, accounting for 1% of overall mortality in the country.<sup>4</sup> The national 2016 STEPS survey report showed that 5.9% (6.0% male and 5.8% females) of Ethiopians had raised blood glucose levels and 98.4% had at least one risk factor for DM.<sup>8</sup>

The burden of DM has an economic implication, affecting the health system, and also adding an extra burden on the affected individuals and their families.<sup>9</sup> For example, globally an estimated gross domestic product loss due to DM, including both the direct and indirect costs, will total US\$ 1.7 trillion, while LMICs have a total loss of US\$ 800 billion due to the unacceptably high burden of DM.<sup>10,11</sup> Besides the economic burden on the health-care system and national economy, DM imposes a catastrophic out-of-pocket personal expenditure from loss of income due to disability and premature death.<sup>11</sup> DM is also a major cause of blindness, kidney failure, heart attacks, stroke, amputation, and death. The negative impacts of DM are unacceptably high as there are effective public health and clinical interventions including a healthy diet, regular physical activity, maintaining normal body weight, and avoiding tobacco use.<sup>1</sup>

Prior community-based studies conducted elsewhere reported the prevalence of DM to range from 1.4% to 19.1%<sup>12–16</sup> with associated factors including age, education status, occupational status, positive family history of DM, fruit and vegetable consumption, physical activity, smoking, and alcohol consumption.<sup>15,17–21</sup> However, to the best of our knowledge, there are no recent population-level studies in Dire Dawa concerning the magnitude of DM and associated factors that help guide informed decisions and the development of strategies. In addition, prior evidence accumulated regarding the prevalence of previously undiagnosed and uncontrolled DM was limited despite being an important public health intervention targeting morbidity, mortality, and improvement in the quality of life.<sup>18,22</sup> Besides, this study used a standardized and validated tool, the World Health

Organization STEPwise approach to non-communicable disease risk factors surveillance (WHO NCD STEPS)<sup>23</sup> with a large community-based sample. In summary, this study aimed to assess the prevalent, uncontrolled, and undiagnosed DM and associated factors among urban adults in Dire Dawa, Eastern Ethiopia.

## Methods and materials

### Study setting and design

A population-based cross-sectional study was conducted from 1 June to 21 June 2017 in Dire Dawa City which is the capital of Dire Dawa Administration and located 515 km east of Addis Ababa, the capital of Ethiopia. The Dire Dawa administration consists of the city of Dire Dawa and the surrounding rural areas. The city has nine urban kebeles (equivalent to a sub-district, the lowest administrative unit) and 28 rural sub-districts. According to the Central Statistical Authority report of 2013, the total population of the administration was 405,444 with a population density of 4530/km<sup>2</sup> (11,700/sq mi); among the total population, 196,777 were male and 208,666 were female.<sup>24</sup>

### Populations

This study obtained data from a sample calculation for a study on metabolic syndrome where 872 participants provided valid observations from a total of 903. A sample size of 903 was calculated using the Open Epi version 3.01,<sup>25</sup> considering a 95% confidence level (CI), 3% degree of precision, 1.5 design effect, and 17% prevalence of metabolic syndrome (MetSyndr) based on the study conducted in Addis Ababa.<sup>26</sup> Eligible participants were adults aged 25–64 years who lived in Dire Dawa for at least 6 months before the survey. Pregnant women, physically and/or mentally disabled individuals, and participants who refused to consent for the study were excluded. A multi-stage random sampling technique was used to select sub-districts, households within the selected sub-districts, and eligible adults in the selected households. From a total of nine urban sub-districts in Dire Dawa City, five were randomly selected. The sample size was proportionally distributed to each of the sub-districts based on the number of households in that administrative unit. A systematic random sampling technique was employed to select households to be visited. During a household visit, the number of adults aged between 25 and 64 years was identified, and if two or more eligible adults were found in a household, a lottery method was used to select one adult for the interview.

### Instruments and data collection

This study used the WHO NCD STEPS instrument which consisted of three steps for measuring the risk of NCD risk factors.<sup>23</sup> The first step consists of a collection of core and expanded socio-demographic and behavioral characteristics

of the study population. The second step involves core and expanded physical measurement, and the third step consists of biochemical measurement.<sup>23</sup> The data collection tool was primarily developed in English and then translated to Amharic and Afan Oromo, the two widely spoken languages in the study setting by language experts. To check for consistency, back translation to the English language was made before data collection. The training was performed on the study objectives and the STEPS survey procedure. A pre-test was conducted in a sub-district that was not included in the study to check that the data collectors and responders understood the questions translated to the local languages and also measures consistency in measurement among the data collectors. Accordingly, necessary adjustments were made before the actual data collection according to the feedback from the pre-test.

Data were collected using a face-to-face interview technique by health-care professionals who had a Bachelor of Science (BSc) in nursing. Before the interview, study participants were informed about the purpose and procedure of the study, and written informed voluntary consent was obtained. Data were collected on weekends and in the afternoon on workdays during which time eligible adults were expected to be at home in the study setting.

### Variable measurements

A digital glucometer (Accu-Chek® blood glucometer; material no. 06453970018; batch/lot no. 496915) was used to measure capillary blood sugar after participants were asked about the time lapsed from the last meal. Capillary blood samples were collected three times on different occasions (for three consecutive days) from a single study participant, and the average of the three measurements was used for analysis to minimize errors. We used the International Diabetes Association's (IDA) definition to define DM: fasting blood glucose (FBG)  $\geq 126$  mg/dL or random blood glucose (RBG)  $> 200$  mg/dL.<sup>3</sup> In addition, subjects who were taking DM medications during the survey were identified as previously diagnosed with DM.<sup>27</sup>

Previously undiagnosed DM was defined as participants who had not had their blood sugar tested before and not taking DM medications during the survey and had an FBG  $\geq 126$  mg/dL or RBG  $> 200$  mg/dL.<sup>3</sup> Similarly, uncontrolled DM (or poor glycemic control) was defined when FBG  $\geq 126$  mg/dL or RBG  $> 200$  mg/dL among those who were taking DM medication during the survey.<sup>1</sup>

Blood pressure (BP) was measured using a semi-automatic BP monitor (Microlife BP A50; Microlife AG, Widnau, Switzerland) three times, each 3–5 min apart, from the left arm while the participant was in a sitting position, and the average value of the last two measurements was used to define hypertension; persistent systolic BP  $\geq 140$  mm Hg or diastolic BP  $\geq 90$  mm Hg or reported use of antihypertensive medication.<sup>28</sup>

Anthropometric measurement was carried out following standard procedures and using calibrated instruments.<sup>29</sup> Weight was measured using a standard digital scale and a stadiometer to measure height, and the results were recorded to the nearest 0.5 cm. Body mass index (BMI) was defined as a person's weight in kilograms divided by the square of the person's height in meters ( $\text{kg}/\text{m}^2$ ) and categorized as follows: BMI  $< 18.5$ , underweight; BMI 18.5–24.9, normal; and BMI  $\geq 25$ , overweight and obese.<sup>30</sup> The digital BP apparatus was used to measure BP. Abdominal obesity was defined as waist circumference: in males  $> 94$  cm and females  $> 80$  cm.<sup>23</sup>

To measure physical activity, the WHO global recommendation on physical activity was used. Accordingly, the combination of moderate- and vigorous-intensity activity accumulating at least 600 metabolic equivalent (MET)-minutes per week was used as a cut-off to define physically active (achieved 600 or more MET-minutes per week) versus inactive adults (achieving less than 600 MET-minutes per week).<sup>23,31</sup>

Current tobacco smoke was defined when a participant reported that he or she smoked tobacco products daily during the data collection period. Similarly, participants who drank alcohol in the past 30 days of the data collection period were considered as current alcohol users.<sup>23</sup>

### Quality control

The data were collected by trained and experienced field staff. The overall data collection process was supervised by research assistants who had a health background and at least had a BSc degree. A 3-day intensive training was given to the data collectors and the supervisors. The data collection instruments were pre-tested on 5% of sample households outside the selected sub-districts in the city to correct possible problems that may arise during actual data collection. The blood glucose test was conducted according to the standard operating procedures. Supervisors and the research team checked the data for completeness on an ongoing basis.

### Data processing and analysis

The data were entered into Epi Data version 3.1 and exported to STATA version 14.2 statistical software. Both descriptive and analytic analyses were performed. The study findings were presented as mean values, percentages with their corresponding 95% CIs, tables, figure, and chi-square tests. Bivariable and multivariable binary logistic regression models were run to identify factors associated with DM. Variables with a p-value of less than 0.25 were considered for the multivariable binary logistic regression. Odds ratio with 95% CI was presented, and the Hosmer–Lemeshow goodness-of-fit test was used to assess model adequacy. All statistical tests were declared significant at p-value  $< 0.05$ . Multicollinearity was checked, and no significant correlation was found among variables included in the multivariable analysis.

**Table 1.** Socio-demographic characteristics of adults aged 25–65 years in Dire Dawa City, 2017 (n = 872).

| Variables   | Imputed analysis data |            | Complete case analysis data |            |
|---|-----------------------|------------|-----------------------------|------------|
|   | Frequency             | Percentage | Frequency                   | Percentage |
| Sex   |                       |            |                             |            |
| Male  | 286                   | 32.8       | 286                         | 32.8       |
| Female  | 586                   | 67.2       | 586                         | 67.2       |
| Age in years <sup>a</sup> , mean (SD) = 40.4 (13.0) |                       |            |                             |            |
| 25–34   | 371                   | 42.6       | 366                         | 42.6       |
| 35–44   | 187                   | 21.4       | 184                         | 21.4       |
| 45–54   | 121                   | 13.9       | 120                         | 13.9       |
| 55–64   | 193                   | 22.1       | 190                         | 22.1       |
| Educational status <sup>a</sup>                     |                       |            |                             |            |
| No formal education                                 | 126                   | 14.4       | 119                         | 14.2       |
| Primary (1–8 grade)                                 | 333                   | 38.2       | 315                         | 37.7       |
| Secondary (9–12 grade)                              | 312                   | 35.8       | 303                         | 36.3       |
| College/University                                  | 101                   | 11.6       | 99                          | 11.8       |
| Marital status                                      |                       |            |                             |            |
| Married   | 582                   | 66.8       | 582                         | 66.8       |
| Not married   | 173                   | 19.8       | 173                         | 19.8       |
| Divorced/widowed                                    | 117                   | 13.4       | 117                         | 13.4       |
| Occupational status                                 |                       |            |                             |            |
| Employed (office work)                              | 232                   | 26.6       | 232                         | 26.6       |
| Merchant  | 119                   | 13.7       | 119                         | 13.7       |
| Unemployed  | 375                   | 43.0       | 375                         | 43.0       |
| Others <sup>b</sup>                                 | 146                   | 16.7       | 146                         | 16.7       |

SD: standard deviation.

<sup>a</sup>Variables for which missing responses were imputed.

<sup>b</sup>Housewives, pensioners, daily laborer, and janitor.

We used multiple imputations by chained equations (MICEs)<sup>32</sup> to handle missing values for five variables which altogether accounted for 14.6% of the data. Before the imputation, we checked for the pattern of these missing values using the Little's test in STATA to check whether missing was completely at random (MCAR) which was defined when the test was not significant.<sup>33</sup>

## Results

### Socio-demographic characteristics

A total of 872 adults participated in the survey with 822 providing complete responses to all the survey items. We used the MICE method to complete the incomplete responses. In this survey, females constituted 67.2% of the study sample and the mean age was 40.4 years. Five hundred and eighty two (66.7%) of the participants were married, and 85.5% had achieved some level of formal education (Table 1).

### Behavioral, diet, and physical measurements

Of the total participants, 8.5% were current cigarette smokers and current smokers were 7.7% among the diabetics. The prevalence of alcohol consumption in the past 30 days before

the survey was 13.6% among all the participants, and it was 13.9% among the diabetics. Two hundred and ninety five (33.8%) and 27.6% ate five or more servings of fruits and vegetables per week, respectively. Regarding physical activity, 44.7% of the total participants did not achieve the recommended 600 MET tasks minutes per week and this was even higher among the diabetics, 51.5%. Among the diabetics, 49% were overweight/or obese and 57% had abdominal obesity. This was high when compared to the prevalence of the same in the total participants: 39% were overweight/or obese versus 46% had abdominal obesity (Table 2).

### Prevalence of DM

The overall prevalence of DM among adults was 14.9% (95% CI: 12.1, 17.4) with 58.5% (95% CI: 49.7, 66.7) taking DM medication during the survey. The prevalence of DM was slightly higher among males than females, 15.0% (95% CI: 11.3, 19.7) versus 14.8% (95% CI: 12.2, 18.0). However, the difference was not statistically significant ( $\chi^2$ (degree of freedom (df))=0.0054 (1), p-value=0.941).

The prevalence of previously undiagnosed DM was 6.2% (95% CI: 4.8, 8.0) in the study sample, and this accounted for 41.5% (95% CI: 33.3, 50.3) of the diabetics. The prevalence of previously undiagnosed DM was significantly higher

**Table 2.** Behavioral, diet, and physical characteristics of adults age 25–65 years in Dire Dawa City, 2017 (n=872).

| Tobacco status  | Total (n=872 (%)) | Diabetes mellitus (DM) <sup>a</sup><br>(n=130 (%)) | DM <sup>b</sup> (n (%)) |
|---|-------------------|--|-------------------------|
| Currently smoke cigarette                               |                   |  |                         |
| Yes   | 74 (8.5)          | 10 (7.7)   | 10 (7.7)                |
| No  | 798 (91.5)        | 120 (92.3)   | 120 (92.3)              |
| Current use of alcohol                                  |                   |  |                         |
| Yes   | 119 (13.6)        | 18 (13.9)  | 18 (13.9)               |
| No  | 753 (86.4)        | 112 (86.1)   | 112 (86.1)              |
| Fruit consumption per week                              |                   |  |                         |
| Two or fewer servings                                   | 467 (53.6)        | 54 (41.5)  | 54 (41.5)               |
| Three to four servings                                  | 110 (12.6)        | 13 (10.0)  | 13 (10.0)               |
| Five or more servings                                   | 295 (33.8)        | 63 (48.5)  | 63 (48.5)               |
| Vegetable consumption per week                          |                   |  |                         |
| Two or fewer serving                                    | 481 (55.2)        | 88 (67.7)  | 88 (67.7)               |
| Three to four servings                                  | 150 (17.2)        | 11 (8.5)   | 11 (8.5)                |
| Five or more servings                                   | 241 (27.6)        | 31 (23.8)  | 31 (23.8)               |
| Physical activity (MET-minutes)                         |                   |  |                         |
| <600  | 390 (44.7)        | 67 (51.5)  | 67 (51.5)               |
| ≥600  | 482 (55.3)        | 63 (48.5)  | 63 (48.5)               |
| Body mass index (BMI) <sup>c</sup> (kg/m <sup>2</sup> ) |                   |  |                         |
| Underweight (<18.5)                                     | 65 (7.5)          | 7 (5.4)  | 7 (6.6)                 |
| Normal (18.5–24.9)                                      | 467 (53.5)        | 60 (46.1)  | 43 (40.6)               |
| Overweight (≥25)  | 340 (39.0)        | 63 (48.5)  | 56 (52.8)               |
| Abdominal obesity                                       |                   |  |                         |
| Yes   | 405 (46.4)        | 74 (56.9)  | 74 (56.9)               |
| No  | 467 (53.6)        | 56 (43.1)  | 56 (43.1)               |

<sup>a</sup>Imputed analysis data.

<sup>b</sup>Complete case analysis data.

<sup>c</sup>Variables for which missing responses were imputed.

among participants with a formal education than with no formal education ( $\chi^2(df)=4.3$  (1),  $p$ -value=0.038). In addition, previously undiagnosed DM was significantly higher among participants with abdominal obesity ( $\chi^2(df)=8.82$  (1),  $p$ -value=0.003) (Table 3).

The prevalence of uncontrolled DM among those taking DM medications during the survey was 30.3% (95% CI: 19.8, 45.6) and was significantly higher among females than males ( $\chi^2(df)=4.73$  (1),  $p$ -value=0.030). Similarly, the prevalence of uncontrolled DM was significantly higher among participants with formal education compared to those with no formal education (Table 3).

### Factors associated with DM

In this study, we identified factors associated with the overall DM including the following: sex, age, educational status, marital status, occupation, current alcohol use, smoking, fruit consumption, vegetable consumption, physical activity, BMI, abdominal obesity, and hypertension. All were considered using bivariate binary logistic regression and four variables with  $p$ -value  $\geq 2.5$  (occupational status, alcohol consumption, fruit consumption, and abdominal obesity) were removed leaving 9 to proceed with the multivariable

binary logistic regression model. In the bivariate model, age, marital status, BMI, and hypertension were significantly associated with DM. Most of the variables significant in the crude analysis also maintained the same in the multivariable model. After controlling for other variables in the multivariable model, age (55–64 years, adjusted odds ratio (AOR) =2.1, 95% CI: 1.2, 3.6), marital status (currently married, AOR=2.3, 95% CI: 1.2, 4.4), and BMI (BMI  $\geq 25$  kg/m<sup>2</sup>, AOR=1.6, 95% CI: 1.1, 2.1) had a higher odds of developing DM compared to the reference groups. However, no formal educational status (AOR=0.5, 95% CI: 0.2, 0.9) and primary school attendance (AOR=0.4, 95% CI: 0.2, 0.8) had lower odds of developing DM (for details, see Table 4).

### Discussion

In this study, the overall prevalence of DM was 14.9% and the prevalence of undiagnosed DM was 6.2% among urban adults aged 25–64 years. Among participants taking DM medications during the survey, 30.3% had uncontrolled DM. The factors that were significantly associated with overall DM in this study included age, educational status, marital status, and BMI. In the bivariable  $\chi^2$  analysis, age, educational status, fruit and vegetable consumption, and abdominal obesity had a

**Table 3.** The prevalence of undiagnosed and uncontrolled DM with participant characteristics, 2017.

|                                | Undiagnosed DM (n = 130) |             | $\chi^2$ (df) | Uncontrolled DM (n = 76) |             | $\chi^2$ (df) |
|--------------------------------|--------------------------|-------------|---------------|--------------------------|-------------|---------------|
|                                | Yes (n = 54)             | No (n = 76) |               | Yes (n = 23)             | No (n = 53) |               |
| Sex                            |                          |             |               |                          |             |               |
| Male                           | 17 (31.5)                | 26 (34.2)   | 0.11 (1)      | 12 (52.2)                | 14 (26.4)   | 4.73 (1)*     |
| Female                         | 37 (68.5)                | 50 (65.8)   |               | 11 (47.8)                | 39 (73.6)   |               |
| Age in years                   |                          |             |               |                          |             |               |
| 25–54                          | 31 (57.4)                | 59 (77.6)   | 6.06 (1)*     | 14 (60.9)                | 45 (84.9)   | 5.34 (1)*     |
| 55+                            | 23 (42.6)                | 17 (22.4)   |               | 9 (39.1)                 | 8 (15.1)    |               |
| Educational status             |                          |             |               |                          |             |               |
| No formal education            | 14 (25.9)                | 9 (11.8)    | 4.30 (1)*     | 7 (30.4)                 | 2 (3.8)     | 10.92 (1)**   |
| Formal education               | 40 (74.1)                | 67 (88.2)   |               | 16 (69.6)                | 51 (96.2)   |               |
| Marital status                 |                          |             |               |                          |             |               |
| Currently married              | 43 (79.6)                | 59 (77.6)   | 0.07 (1)      | 16 (69.6)                | 43 (81.1)   | 1.24 (1)      |
| Currently unmarried            | 11 (20.4)                | 17 (22.4)   |               | 7 (30.4)                 | 10 (18.9)   |               |
| Fruit consumption per week     |                          |             |               |                          |             |               |
| <Five servings                 | 20 (37.0)                | 47 (61.8)   | 7.78 (1)*     | 16 (69.6)                | 31 (58.5)   | 0.83 (1)      |
| Five or more servings          | 34 (63.0)                | 29 (38.2)   |               | 7 (30.4)                 | 22 (41.5)   |               |
| Vegetable consumption per week |                          |             |               |                          |             |               |
| Fewer than five servings       | 47 (87.0)                | 52 (68.4)   | 6.02 (1)*     | 17 (73.9)                | 35 (66.0)   | 0.46 (1)      |
| Five or more servings          | 7 (13.0)                 | 24 (31.6)   |               | 6 (26.1)                 | 18 (34.0)   |               |
| Body mass index (BMI)          |                          |             |               |                          |             |               |
| <25 kg/m <sup>2</sup>          | 25 (46.3)                | 42 (55.3)   | 1.02 (1)      | 7 (30.4)                 | 35 (66.0)   | 8.22 (1)*     |
| ≥25 kg/m <sup>2</sup>          | 29 (53.7)                | 34 (44.7)   |               | 16 (69.6)                | 18 (34.0)   |               |
| Abdominal obesity              |                          |             |               |                          |             |               |
| Yes                            | 39 (72.2)                | 35 (46.1)   | 8.82 (1)*     | 13 (56.5)                | 22 (41.5)   | 1.45550 (1)   |
| No                             | 15 (27.8)                | 41 (53.9)   |               | 10 (43.5)                | 31 (58.5)   |               |

DM: diabetes mellitus; df: degree of freedom.

\* $p < 0.05$ ; \*\* $p < 0.01$ .

significant association with previously undiagnosed DM; in addition, age, sex, educational status, and BMI were significantly associated with uncontrolled DM.

The 14.9% prevalence of DM among adults in Dire Dawa identified in our study was higher than the estimates reported in sub-national studies conducted in Ethiopia ranging from 5.1% in Northwest Ethiopia to 11.5% in East Gojjam.<sup>18,20,27</sup> The current finding is also higher compared to different sub-national studies in Africa which reported the prevalence ranging from 1.4% in Uganda to 7.2% in Western Cape.<sup>16,17,19,34</sup> Our finding, however, is comparable with a 12.1% prevalence of DM by Bahijiri et al.<sup>35</sup> in Saudi Arabia and a 13% prevalence of DM by Idris et al.<sup>36</sup> in Indonesia. The observed higher prevalence of DM in our study compared to others could be due to variations in the level of difference in the family history of diabetes,<sup>37</sup> which we did not measure in our study, and may be due to an increased prevalence of higher BMI and abdominal obesity in the study setting. Besides, a higher unemployment rate and poor consumption of fruits and vegetables in the study setting may also have contributed to the observed differences. Previous observational studies conducted elsewhere reported that high exposure to unemployment was related to prediabetes and type 2 diabetes.<sup>38,39</sup> The protective effect of fruit and

vegetable consumption against the risk of type 2 DM was established in previous studies reported in a systematic review and meta-analysis.<sup>40</sup>

The magnitude of undiagnosed DM in this study was 6.2% (95% CI: 4.8, 8.0) with a prevalence of 41.5% among the diabetics. The 6.2% prevalence of undiagnosed DM in our study was comparable with a 5.3% pooled prevalence of undiagnosed DM by Asmelash and Asmelash<sup>41</sup> in African adults although the same study reported an 8.7% prevalence among urban adults. The prevalence of previously undiagnosed diabetes among adults with diabetes in our study was also comparable to the 2014 global estimate of 45.8% although regional variations range from 24.1% to 75.1%.<sup>42</sup> Our finding suggests that the magnitude of previously undiagnosed DM needs the attention of public health agencies and efforts should be directed to design a feasible means of establishing a system that enables community screening, which is useful for early diagnosis and prevention of premature death from complications due to undiagnosed DM.<sup>43</sup>

In this study, 30.3% of participants taking DM medication did not achieve the target blood glucose levels. Our study finding indicates that diabetics in the study setting had better glycemic control compared to studies reporting a higher rate of poor glycemic control ranging from 53.3% in Saudi Arabia

**Table 4.** Multi-level correlates of diabetes mellitus among adults in Dire Dawa, Eastern Ethiopia, 2017.

| Characteristics                          | Imputed data analysis |                 | Complete case data analysis |                 |
|--|-----------------------|-----------------|-----------------------------|-----------------|
|  | COR (95% CI)          | AOR (95% CI)    | COR (95% CI)                | AOR (95% CI)    |
| <b>Sex</b>                               |                       |                 |                             |                 |
| Male                                     | 1.1 (0.7, 1.5)        | 1.1 (0.7, 1.6)  | 1.1 (0.7, 1.6)              | 1.1 (0.7, 1.7)  |
| Female                                   | Ref.                  | Ref.            | Ref.                        | Ref.            |
| <b>Age in years<sup>a</sup></b>          |                       |                 |                             |                 |
| 25–34                                    | Ref.                  | Ref.            | Ref.                        | Ref.            |
| 35–44                                    | 1.4 (0.8, 2.4)        | 1.2 (0.7, 2.1)  | 1.3 (0.8, 2.4)              | 1.5 (0.8, 2.9)  |
| 45–54                                    | 1.9 (1.1, 3.4)*       | 1.5 (0.8, 2.8)  | 1.8 (1.0, 3.3)*             | 1.8 (1.1, 3.8)* |
| 55–64                                    | 2.2 (1.3, 3.5)*       | 2.1 (1.2, 3.6)* | 2.3 (1.4, 3.8)*             | 2.8 (1.4, 5.7)* |
| <b>Educational status<sup>a</sup></b>    |                       |                 |                             |                 |
| No formal education                      | 1.1 (0.5, 2.0)        | 0.5 (0.2, 0.9)* | 0.8 (0.4, 1.6)              | 0.3 (0.1, 0.8)* |
| Primary (1–8 grade)                      | 0.6 (0.4, 1.2)        | 0.4 (0.2, 0.8)* | 0.7 (0.4, 1.3)              | 0.4 (0.2, 0.9)* |
| Secondary (9–12 grade)                   | 0.8 (0.5, 1.5)        | 0.7 (0.4, 1.2)  | 0.8 (0.4, 1.5)              | 0.6 (0.3, 1.2)  |
| College/university                       | Ref.                  | Ref.            | Ref.                        | Ref.            |
| <b>Marital status</b>                    |                       |                 |                             |                 |
| Never married                            | Ref.                  | Ref.            | Ref.                        | Ref.            |
| Currently married                        | 2.6 (1.4, 4.8)*       | 2.3 (1.2, 4.4)* | 2.6 (1.3, 4.9)*             | 2.0 (1.0, 4.1)* |
| Widowed/divorced                         | 1.8 (0.8, 4.0)        | 1.5 (0.7, 3.6)  | 1.8 (0.8, 4.3)              | 1.3 (0.5, 3.3)  |
| <b>Currently smoke tobacco products</b>  |                       |                 |                             |                 |
| Yes                                      | 0.9 (0.4, 1.8)        | 0.9 (0.4, 1.9)  | 0.9 (0.4, 1.8)              | 0.9 (0.4, 1.9)  |
| No                                       | Ref.                  | Ref.            | Ref.                        | Ref.            |
| <b>Vegetable consumption per week</b>    |                       |                 |                             |                 |
| Two or fewer servings                    | 1.5 (0.97, 2.4)       | 1.5 (0.96, 2.5) | 1.4 (0.9, 2.3)              | 1.2 (0.7, 2.1)  |
| Three to four servings                   | 0.5 (0.3, 1.1)        | 0.5 (0.3, 1.1)  | 0.4 (0.2, 1.1)              | 0.4 (0.2, 1.1)  |
| Five or more servings                    | Ref.                  | Ref.            | Ref.                        | Ref.            |
| <b>Physical activity</b>                 |                       |                 |                             |                 |
| ≤600 MET-minutes                         | 1.4 (0.9, 2.0)        | 1.1 (0.7, 1.6)  | 1.4 (0.9, 2.1)              | 1.2 (0.8, 1.8)  |
| ≥600 MET-minutes                         | Ref.                  | Ref.            | Ref.                        | Ref.            |
| <b>Body mass index (BMI)<sup>a</sup></b> |                       |                 |                             |                 |
| Underweight                              | 0.8 (0.4, 1.9)        | 0.8 (0.3, 1.8)  | 1.1 (0.5, 2.6)              | 1.1 (0.5, 2.7)  |
| Overweight                               | 1.5 (1.1, 2.3)*       | 1.6 (1.1, 2.1)* | 2.0 (1.3, 3.0)*             | 1.7 (1.1, 2.6)* |
| Normal                                   | Ref.                  | Ref.            | Ref.                        | Ref.            |
| <b>Hypertension (HTN)</b>                |                       |                 |                             |                 |
| Yes                                      | 1.7 (1.2, 2.6)*       | 1.3 (0.8, 2.0)  | 2.1 (1.4, 3.2)*             | 1.5 (0.9, 2.4)  |
| No                                       | Ref.                  | Ref.            | Ref.                        | Ref.            |

Ref.: reference category; COR: crude odds ratio; CI: confidence interval; AOR: adjusted odds ratio.

<sup>a</sup>Variables for which missing responses were imputed.

\* $p < 0.05$ .

to 80% in Addis Ababa.<sup>44–46</sup> Although we found a lower proportion of adults with uncontrolled diabetes compared with studies in other settings, it is still too high as the main aim of DM treatment is to achieve glycemic control at an individual level as this is an important predictor for diabetic complication and death.<sup>47,48</sup> Thus, integrated clinical and community health intervention should be planned to achieve glycemic control and reduce complications and premature death.

Regarding the correlates of DM, consistent with our findings, several studies reported that the prevalence of overall DM was higher among adults aged over 55 years.<sup>35,49,50</sup> As people age, the tendency to exercise less, lose muscle mass, and weight gain increases, and this, in turn, may increase the

risk of DM.<sup>51</sup> Besides, as an individual gets older, the dynamic regeneration capacity of the pancreatic  $\beta$ -cell to maintain euglycemia reduces. The effect of age on the  $\beta$ -cell proliferation and function indirectly contributes to an impaired insulin sensitivity mediated by lifestyle and comorbidity-related risk factors.<sup>52</sup> Consistent with the previous report by Selvin and Parrinello<sup>53</sup> and Fiagbe et al.,<sup>54</sup> age was also significantly associated with uncontrolled DM. Therefore, with an increase in age, adults should take advantage of adhering to modifiable risk factors including a healthy diet, regular physical activity, maintaining normal body weight, and avoiding alcohol and tobacco use<sup>5</sup> to reduce the deteriorating effect to that of age.

Corroborating with the findings of previous studies,<sup>13,35,49,55</sup> DM is more likely to occur among overweight and obese adults. Biologically explained, the body of people who are overweight or obese has a limited capacity to use insulin for optimal blood glucose control due to the release of essential factors that lead to the development of insulin resistance.<sup>56,57</sup> Moreover, the presence of ectopic fat and brown adipose tissues among overweight and obese also expose individuals to the DM.<sup>58</sup> Therefore, routine public health DM-related education campaigns may help to create awareness on lifestyle modifications and the necessity of weight reduction. As the obesity epidemic drives the prevalence of DM, well expressed with the term “diabesity” in Bhupathiraju et al.,<sup>59</sup> focusing on measures to reduce overweight and obesity may have a positive effect in reducing the prevalence of DM.

Against the established evidence that vegetable and fruit consumption is associated with a reduced risk of diabetes,<sup>40,60,61</sup> we did not find a statistically significant association. The lack of association in our study might be primarily due to the very low prevalence of fruit and vegetable consumption among adults in the study setting. In the bivariable analysis, however, fruit and vegetable consumption was significantly associated with undiagnosed DM. This is consistent with the study conducted by Ford and Mokdad.<sup>62</sup>

In this study, the occurrence of DM was lower among participants who had primary or no formal education. This finding is in line with a sub-national study in Ghana<sup>14</sup> and might be due to an increase in sedentary lifestyle with higher education and lower physical activities as they were more likely to be employed in an office setting.<sup>63,64</sup> Also, people with a lower level of education are more likely to be engaged in physically laborious activities for work compared to those with a higher educational status<sup>65</sup> which, in turn, will lower their risk of DM. However, the finding is contrary to the study conducted in Jeddah, Saudi Arabia,<sup>35</sup> Belgrade, Serbia,<sup>66</sup> and European countries.<sup>67</sup> Inconsistent with the previous studies,<sup>68,69</sup> we found that married adults had increased odds of having DM compared with unmarried adults. Previous studies reported that unmarried men had a reduced odds of having type 2 DM,<sup>69</sup> whereas another study reported that married women had no significant difference in the risk of having DM compared with the unmarried or widow/separated.<sup>68</sup> Therefore, we hypothesize that the quality of a marriage or home environment may influence health outcomes. For example, Leong et al.<sup>70</sup> reported that a spousal history of diabetes increased the risk of DM. However, in our study, we did not assess whether individual developed DM before or after marriage making further explanation difficult on the association between DM and marital status.

### **The strength**

We estimated the population-level prevalence of DM disaggregated by previous diagnosis status and reported the level

of glycemic control using the standard STEPS survey tool in a large sample of urban adults. To identify previously undiagnosed elevated blood glucose levels, we collected blood sugar measurements instead of relying on self-reports.

### **Limitations**

While sharing the methodological limitation of cross-sectional studies with others, the effects of income or wealth, family history of diabetes, khat chewing, and eating behaviors other than fruits and vegetables were not assessed. We also did not identify the specific types of fruits or vegetables consumed. The study also did not consider acute and chronic illnesses which may affect blood sugar levels.

### **Conclusion**

The overall prevalence of DM among adults in Dire Dawa was high, and the prevalence of previously undiagnosed DM and poor glycemic control were of great concern. Age, educational status, marital status, and BMI were significantly associated with DM. Therefore, creating awareness through activities targeting adults and identified factors should be devised and institutionalized in the health system in the study setting. Campaigns and community mobilizations to educate the community about early screening and preventive packages targeting modifiable risk factors should be employed to reduce the burden of DM.

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### **Author contributions**

B.H.A., H.S.R., A.S.B., and M.M.M. conceived and designed the study. B.H.A., H.S.R., and M.M.M. adopted data collection instrument and acquisition of data. B.H.A., M.M.M., and H.S.R. carried out the data management. B.H.A. and M.M.M. analyzed the data and interpreted findings. B.H.A. and M.M.M. drafted the manuscript. B.H.A., H.S.R., A.S.B. and M.M.M. performed the critical revision and approval of the final manuscript.

### **Declaration of conflicting interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### **Ethical approval**

Ethical clearance was obtained from the Institutional Health Research Ethics Review Committee of Haramaya University College of Health and Medical Science (HU, IHRERC) with an approval no. IHRERC/003/ 2016. In addition, permission was obtained from the Dire Dawa City Administration. Based on the objective of the study,



an official letter was sent to the selected kebeles in Dire Dawa City Administration. Confidentiality was maintained and all respondents' questionnaire was prepared anonymously.

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### Informed consent

The objective of the study was explained to each study participants. Verbal and written informed consent was obtained from each respondent before the interview. Those volunteers and signed on the consent form were involved in the study. Participants with newly diagnosed diabetes and hypertension were referred to nearby health facilities for further investigation and prompt management.

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### Availability of data and materials

The data sets used and/or analyzed during this study will be available from the corresponding author on reasonable request.

### Supplemental material

Supplemental material for this article is available online.

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